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PHILOSOPHICAL
TRANSACTIONS
OF THE
ROYAL SOCIETY
OF
LONDON.

FOR THE YEAR MDCCCLX.

VOL. 150.—PART I.

LONDON:

PRINTED BY TAYLOR AND FRANCIS, RED LION COURT, FLEET STREET.

MDCCCLX.

ADVERTISEMENT.

THE Committee appointed by the *Royal Society* to direct the publication of the *Philosophical Transactions*, take this opportunity to acquaint the Public, that it fully appears, as well from the Council-books and Journals of the Society, as from repeated declarations which have been made in several former *Transactions*, that the printing of them was always, from time to time, the single act of the respective Secretaries till the Forty-seventh Volume; the Society, as a Body, never interesting themselves any further in their publication, than by occasionally recommending the revival of them to some of their Secretaries, when, from the particular circumstances of their affairs, the *Transactions* had happened for any length of time to be intermitted. And this seems principally to have been done with a view to satisfy the Public, that their usual meetings were then continued, for the improvement of knowledge, and benefit of mankind, the great ends of their first institution by the Royal Charters, and which they have ever since steadily pursued.

But the Society being of late years greatly enlarged, and their communications more numerous, it was thought advisable that a Committee of their members should be appointed, to reconsider the papers read before them, and select out of them such as they should judge most proper for publication in the future *Transactions*; which was accordingly done upon the 26th of March 1752. And the grounds of their choice are, and will continue to be, the importance and singularity of the subjects, or the advantageous manner of treating them; without pretending to answer for the certainty of the facts, or propriety of the reasonings, contained in the several papers so published, which must still rest on the credit or judgement of their respective authors.

It is likewise necessary on this occasion to remark, that it is an established rule of the Society, to which they will always adhere, never to give their opinion, as a Body, upon any subject, either of Nature or Art, that comes before them. And therefore the

thanks, which are frequently proposed from the Chair, to be given to the authors of such papers as are read at their accustomed meetings, or to the persons through whose hands they received them, are to be considered in no other light than as a matter of civility, in return for the respect shown to the Society by those communications. The like also is to be said with regard to the several projects, inventions, and curiosities of various kinds, which are often exhibited to the Society; the authors whereof, or those who exhibit them, frequently take the liberty to report and even to certify in the public newspapers, that they have met with the highest applause and approbation. And therefore it is hoped that no regard will hereafter be paid to such reports and public notices; which in some instances have been too lightly credited, to the dishonour of the Society.

The Meteorological Journal hitherto kept by the Assistant Secretary at the Apartments of the Royal Society, by order of the President and Council, and published in the Philosophical Transactions, has been discontinued. The Government, on the recommendation of the President and Council, has established at the Royal Observatory at Greenwich, under the superintendence of the Astronomer Royal, a Magnetical and Meteorological Observatory, where observations are made on an extended scale, which are regularly published. These, which correspond with the grand scheme of observations now carrying out in different parts of the globe, supersede the necessity of a continuance of the observations made at the Apartments of the Royal Society, which could not be rendered so perfect as was desirable, on account of the imperfections of the locality and the multiplied duties of the observer.

A List of Public Institutions and Individuals, entitled to receive a copy of the Philosophical Transactions of each year, on making application for the same directly or through their respective agents, within five years of the date of publication.

Observatories.

| | |
|--------------------|---------------------|
| Armagh. | Kew. |
| Cape of Good Hope. | Liverpool. |
| Dublin. | Madras. |
| Edinburgh. | Oxford (Radcliffe). |
| Greenwich. | |

Institutions.

| | |
|-------------|-------------------------------------|
| Barbadoes. | Library and Museum. |
| Calcutta. | Asiatic Society. |
| | Geological Museum. |
| Cambridge. | Philosophical Society. |
| Dublin. | Royal Dublin Society. |
| | Royal Irish Academy. |
| Edinburgh. | Royal Society. |
| London. | Admiralty Library. |
| | Chemical Society. |
| | Entomological Society. |
| | Geological Society. |
| | Geological Survey of Great Britain. |
| | Horticultural Society. |
| | Institute of British Architects. |
| | Institution of Civil Engineers. |
| | Linnean Society. |
| | London Institution. |
| | Medical and Chirurgical Society. |
| | Queen's Library. |
| | Royal Asiatic Society. |
| | Royal Astronomical Society. |
| | Royal College of Physicians. |
| | Royal Geographical Society. |
| | Royal Institution of Great Britain. |
| | Royal Society of Literature. |
| | Society of Antiquaries. |
| | Society of Arts. |
| | The Treasury Library. |
| | United Service Museum. |
| | Zoological Society. |
| Malta. | Public Library. |
| Manchester. | Literary and Philosophical Society. |
| Oxford. | Ashmolean Society. |
| | Radcliffe Library. |
| Swansea. | Royal Institution. |
| Sydney. | University Library. |
| Woolwich. | Royal Artillery Library. |

Belgium.

| | |
|-----------|----------------------------|
| Brussels. | Royal Academy of Sciences. |
|-----------|----------------------------|

Denmark.

| | |
|-------------|----------------------------|
| Altona. | Royal Observatory. |
| Copenhagen. | Royal Society of Sciences. |

France.

| | |
|-----------|-----------------------|
| Paris. | Academy of Sciences. |
| | Dépôt de la Marine. |
| | Ecole des Mines. |
| | Geographical Society. |
| | Geological Society. |
| | Jardin des Plantes. |
| Toulouse. | Academy of Sciences. |

Germany.

| | |
|------------|-------------------------------------|
| Berlin. | Royal Academy of Sciences. |
| | Society of Experimental Philosophy. |
| Bonn. | Cæsarean Acad. of Naturalists. |
| Frankfort. | Natural History Society. |
| Giessen. | University. |
| Göttingen. | University. |
| Hamburg. | Naturwissenschaftlicher-Verein. |
| Leipzig. | Royal Saxon Society of Sciences. |
| Mannheim. | Observatory. |
| Munich. | Royal Academy of Sciences. |
| Prague. | Bohemian Society of Sciences. |
| Vienna. | Imperial Academy of Sciences. |
| Würzburg. | Physico-Medical Society. |

Hungary.

| | |
|--------|--------------------------------|
| Pesth. | Hungarian Academy of Sciences. |
|--------|--------------------------------|

Italy.

| | |
|---------|---|
| Milan. | Institute of Sciences, Letters and Arts. |
| Modena. | Italian Society of Sciences. |
| Naples. | Institute of Sciences. |
| Rome. | Academy de' Nuovi Lincei. |
| | Collegio Romano. |
| Turin. | Royal Academy of Sciences. |
| Venice. | Institute of Sciences, Letters, and Arts. |

Java.

| | |
|----------|-------------------------------|
| Batavia. | Batavian Society of Sciences. |
|----------|-------------------------------|

Netherlands.

| | |
|------------|--|
| Amsterdam. | Royal Institute. |
| Haarlem. | Dutch Society of Sciences. |
| Rotterdam. | Batavian Society of Experimental Philosophy. |

Portugal.

| | |
|---------|----------------------------|
| Lisbon. | Royal Academy of Sciences. |
|---------|----------------------------|

Russia.

| | |
|-----------------|----------------------------------|
| Moscow. | Imperial Society of Naturalists. |
| Pulkowa. | Observatory. |
| St. Petersburg. | Imperial Academy of Sciences. |

Spain.

| | |
|---------|----------------------------|
| Cadiz. | Observatory. |
| Madrid. | Royal Academy of Sciences. |

Sweden and Norway.

| | |
|------------|----------------------------|
| Drontheim. | Royal Society of Sciences. |
| Stockholm. | Royal Academy of Sciences. |

Switzerland.

| | |
|---------|--|
| Bern. | Allg. Schweizerischen Gesellschaft. |
| Geneva. | Société de Phys. et d'Hist. Naturelle. |

United States.

| | |
|---------------|------------------------------------|
| Albany. | New York State Library. |
| Boston. | American Academy of Sciences. |
| | The Editors of Silliman's Journal. |
| Cambridge. | Harvard University. |
| Philadelphia. | American Philosophical Society. |
| Washington. | Smithsonian Institution. |
| | Observatory. |

The *fifty* Foreign Members of the Royal Society.

A List of Public Institutions and Individuals, entitled to receive a copy of the Astronomical Observations (including Magnetism and Meteorology) made at the Royal Observatory at Greenwich, on making application for the same directly or through their respective agents, within two years of the date of publication.

| <i>Observatories.</i> | <i>Institutions.</i> |
|-----------------------|--|
| Altona. | Aberdeen University. |
| Armagh. | Berlin Academy. |
| Berlin. | Bologna Academy. |
| Breslau. | Boston American Academy of Sciences. |
| Brussels. | Brunswick, U.S. Bowdoin College. |
| Cadiz. | Cambridge Trinity College Library. |
| Cambridge. | Cambridge, U.S. Harvard University. |
| Cape of Good Hope. | Dublin University. |
| Coimbra. | Edinburgh University. |
| Copenhagen. | Royal Society. |
| Dorpat. | Glasgow University. |
| Dublin. | Göttingen University. |
| Edinburgh. | Leyden University. |
| Helsingfors. | London Board of Ordnance. |
| Königsberg. | Queen's Library. |
| Madras. | Royal Institution. |
| Mannheim. | Royal Society. |
| Marseille. | Oxford Savilian Library. |
| Milan. | Paris Academy of Sciences. |
| Munich. | Board of Longitude. |
| Oxford. | Dépôt de la Marine. |
| Palermo. | Pesth Hungarian Academy. |
| Paris. | Philadelphia American Philosophical Society. |
| Seeberg. | St. Andrews University. |
| Trevandrum. | St. Petersburg Imperial Academy. |
| Tübingen. | Stockholm Royal Academy of Sciences. |
| Turin. | Upsal Royal Society. |
| Vienna. | Waterville, Maine (U.S.) College. |
| Wilna. | |
| | <i>Individuals.</i> |
| | Christie, S. H., Esq. Twickenham. |
| | Lubbock, Sir John William, Bart. London. |
| | Lowndes Professor of Astronomy Cambridge. |
| | Plumian Professor of Astronomy Cambridge. |
| | President of the Royal Society London. |
| | Ross, Rear-Admiral Sir J. C. Aylesbury. |
| | Smyth, Vice-Admiral W. H. Aylesbury. |
| | South, Sir James Kensington. |
| | The Earl of Rosse Parsonstown. |

A List of Observatories, Institutions and Individuals, entitled to receive a Copy of the
Magnetical and Meteorological Observations made at the Royal Observatory, Greenwich.

Observatories.

| | |
|-----------------------------|------------------------|
| Bombay | |
| Cairo | |
| Cambridge, United States .. | Prof. J. Lovering. |
| Christiania | C. Hansteen. |
| Gotha | |
| Heidelberg | M. Tiedemann. |
| Kew | B. Stewart. |
| Kremsmünster | P. A. Reslhuber. |
| Leipsic | Professor Möbius. |
| Marburg | Professor Gerling. |
| Prague | K. Jelinek. |
| Stockholm | Professor H. Selander. |
| Toronto | Professor Kingston. |
| Upsal | Professor Svanberg. |
| Washington | Com. Maury, U.S. Navy. |

Institutions.

| | |
|--------------------------------------|---|
| Bombay | Geographical Society. |
| Bonn | University. |
| The Public Library (late Bowditch).. | Boston, U.S. |
| Cambridge | Philosophical Society. |
| Cherkow | University. |
| Falmouth | Royal Cornwall Poly- technic Society. |
| London | House of Lords, Library. House of Commons, Li- brary. King's College. Royal Society. University College, Li- brary. |
| Oxford | Radcliffe Observatory. |
| Paris | Meteorological Society. |
| St. Bernard | Convent. |
| Washington | Smithsonian Institution. |
| Woolwich | Office of Mag. and Met. Publication. |

Individuals.

| | |
|---|----------------------|
| Bache, Dr. A. D. | Washington. |
| Barlow, P., Esq. | Charlton. |
| Ballot, Dr. Buys. | Utrecht. |
| Dove, Prof. H. W. | Berlin. |
| Erman, Dr. Adolph | Berlin. |
| Fox, R. W., Esq. | Falmouth. |
| Gilliss, Lt. J. M., U.S. Navy.. | Washington. |
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| Howard, Luke, Esq. | Tottenham. |
| Kaemtz, Prof. L. F. | Dorpat. |
| Kreil, Prof. K. | Vienna. |
| Kupffer, A. T. | St. Petersburg. |
| (Twelve copies for distribution to the Russian Mag. and Met. Obs.) | |
| Lloyd, Rev. Dr. | Dublin. |
| Loomis, Prof. E. | New York University. |
| Lovering, Prof. J. | Cambridge, U.S. |
| Pegado, Dr. | Lisbon. |
| Phillips, Prof. John | Oxford. |
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ERRATA IN VOL. 149.

Page 743, line 9, *for* 774 indicated horse-power *read* 744 indicated horse-power.

— 744, line 9, after the words marine boilers, *insert* the engine had been in some respects modified by the makers, Messrs. J. M. ROWAN and Co.; and in particular, a surface condenser designed by them had been substituted for the former surface condenser.

ERRATUM IN VOL. 150.

Page 283, line 21, *for* DELIQUIERE *read* LEREILLÉ.

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ADJUDICATION of the MEDALS of the ROYAL SOCIETY for the year 1860 by
the PRESIDENT and COUNCIL.

The COPLEY MEDAL to Professor ROBERT WILHELM BUNSEN, of Heidelberg, Foreign Member of the Royal Society, for his Researches on Cacodyl, Gaseous Analysis, the Volcanic Phenomena of Iceland, and other Researches.

A ROYAL MEDAL to Mr. WILLIAM FAIRBAIRN, F.R.S., for his various Experimental Inquiries on the Properties of the Materials employed in Mechanical Construction, contained in the Philosophical Transactions and in the Publications of various Scientific Societies.

A ROYAL MEDAL to Dr. AUGUSTUS V. WALLER, F.R.S., for his Investigations into the Anatomy and Physiology of the Nervous System, and for the introduction of a valuable Method of conducting such investigations.

The RUMFORD MEDAL to Professor J. CLERK MAXWELL, for his Researches on the Composition of Colours, and other Optical Papers.

The BAKERIAN LECTURE was delivered by Mr. WILLIAM FAIRBAIRN, F.R.S., and entitled "Experimental Researches to determine the Density of Steam at all Temperatures, and to determine the Law of Expansion of Superheated Steam."

The CROONIAN LECTURE was delivered by Mr. JAMES PETTIGREW, and entitled "On the Arrangement of the Muscular Fibres of the Ventricular Portion of the Heart of the Mammal."

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ERRATA IN VOL. 149.

Page 743, line 9, for 774 indicated horse-power read 744 indicated horse-power.

— 744, line 9, after the words marine boilers, insert the engine had been in some respects modified by the makers, MESSRS. J. M. ROWAN and Co.; and in particular, a surface condenser designed by them had been substituted for the former surface condenser.

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Page 283, line 21, for DELIQUIERE read LEREILLÉ.

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